RESEARCH DEPARTMENT

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TECHNOLOGICAL REPORT No. K - 179

1965/11

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

BANDS I AND II MEDIUM DISTANCE PROPAGATION MEASUREMENTS ON OVERLAND PATHS

Technological Report No. K-179
(1965/11)

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for Head of Research Department

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SUMMARY

Field strength measurements were made over several overland transmission paths on Bands I and II, at distances up to 170 miles (274 km). The measurements when corrected for transmitting aerial height above mean terrain and also for receiving site variation factor give field-strength/distance curves which are in reasonable agreement with the current CCIR tropospheric propagation curves.

The range of fading and field strength exceeded in each month for specified time-percentages are also discussed.

1. INTRODUCTION

During 1959 the EBU submitted a document to the CCIR Study Group V in the form of a draft study programme which pointed out the desirability of obtaining statistical information on the fading characteristics of v.h.f. and u.h.f. signals within the distance range 0-200 km. The importance of this information arose from the fact that with the planning of v.h.f. and u.h.f. transmitter networks minimum distance separations between transmissions on adjacent or image channels might be relatively small, whereas the separation distances of co-channel stations could be readily assessed by means of the then existing (and subsequently revised) CCIR tropospheric propagation curves. The CCIR Los Angeles Plenary Assembly accepted the draft study programme, which was then formulated as Study Programme No. 140 and subsequently revised as part of the current Study Programme No. 189 of the Geneva Assembly in 1963.

This report describes measurements made by the BBC during 1961 and 1962 which are to be submitted to the CCIR as a contribution to the Study Programmes.

Field strength records were made of a selection of BBC transmissions over paths ranging in length from 38·5 miles (62 km) to 170 miles (274 km). Two receiving sites were used, one at the BBC Monitoring Station, Caversham Park, Oxfordshire, and the other at an unattended radio station at Mursley, Buckinghamshire. Four Band I television sound and four Band II f.m. sound broadcasting transmissions were measured at each of the receiving sites, giving in all propagation data for sixteen transmission

paths. The measurements were carried out over the period from June 1961 to December 1962. Further measurements were made during the latter half of 1963 for the purpose of obtaining corrections for normalizing the long-term measured field strengths to be representative for 50% of locations.

2. SITES, EQUIPMENT AND ANALYSIS

2.1. Sites

Fig. 1 shows the geographical distribution of the transmitting and receiving sites. Further details of the sites are also given in Tables 1 and 2.

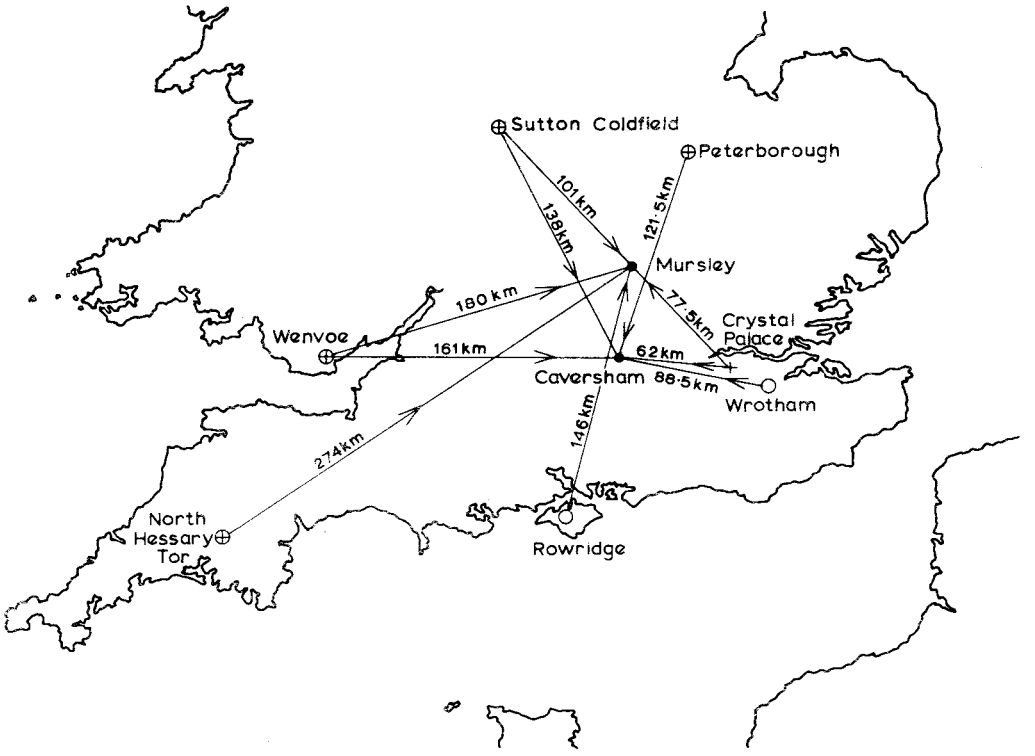


Fig. 1 - Geographical distribution of transmitting and receiving sites

- • Receiving sites
- + Transmitting site (Band I)
- ○ Transmitting site (Band II)
- ⊕ Transmitting sites (Bands I and II)

2.2. Equipment

The Bands I and II receivers used for the field strength measurements, and the equipment facilitating the automatic analysis of the data, have already been described in a Research Department Report.[1]

The main features of the receivers are their reliability and gain stability when used over a long period of time. The Band I receiver intermediate frequency is 270 kc/s and the selectivity response is substantially constant over ± 5 kc/s, falling

by 45 dB at ± 20 kc/s. This narrow passband rejects the sound carriers of other co-channel transmitters offset by 20 kc/s. The Band II receiver intermediate frequency is 2·2 Mc/s and the selectivity response is reasonably constant over a range of ± 40 kc/s, falling by 6 dB at ± 75 kc/s and 50 dB at ± 200 kc/s. The receivers for both bands have a logarithmic input/output characteristic over a range of 50 dB, but the overall gain of the receivers may be adjusted to suit the median signal for a particular path by means of attenuators inserted between the signal-frequency and intermediate-frequency units.

At the receiving sites, the output of each receiver was connected to a voltage coder which was common to the eight receivers. The coder sampled the signal of each receiver sequentially and, depending upon the field strength value, converted it to one of thirty-one levels of a five-unit binary code. The signal level was then recorded on punched paper tape. The time required for a complete cycle for sampling the output of the eight receivers was four minutes and the signal from each receiver was thus sampled fifteen times per hour.

Pen recorders were also connected to the outputs of the receivers to provide signal records that could be visually examined for the presence of interference and for occasional checking of the accuracy of the punched paper tape data. The recording charts were run at a speed of 2 inches (5·1 cm) per hour.

Conventional commercial-type Bands I and II dipoles or 'H' aerials were used at the receiving sites. At Caversham they were mounted on the top of a building at a height of approximately 36 ft (11 m) above ground level (a.g.l.). Similar aerials were used at Mursley, mounted on tubular masts at a height of about 30 ft (9·1 m) a.g.l.

2.3. Analysis

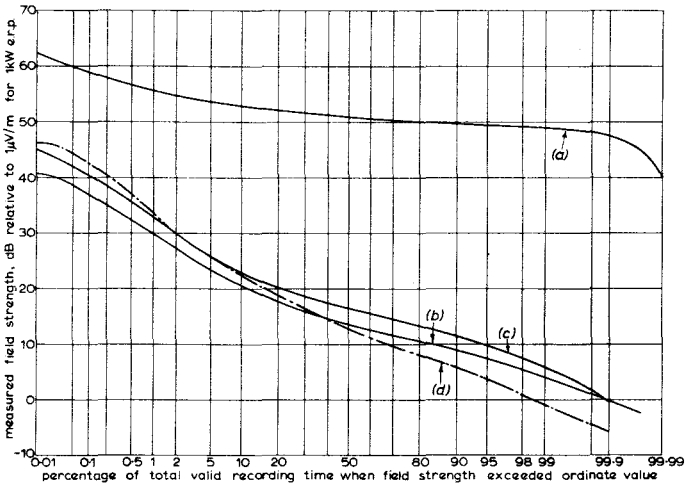
The punched tape at each receiving site was renewed at the end of every month and the used tape returned to base for analysis. Originally, the tape containing the field strength data was fed into a thirty-one level analyser[1] which counted the number of times each level of field strength was recorded. The field strength exceeded for certain fixed time-percentages was then manually calculated from the cumulative distribution of the sampled data. During the series of measurements, however, the BBC had acquired an Elliott 803B computer and the work of analysing the punched tape was subsequently transferred to the computer.

The records of the measurements were analysed to determine the length of time during which the signal levels exceeded various values of field strength. These time durations, expressed as percentages of the overall valid recording time, were then plotted against field strength normalised for an effective radiated power (e.r.p.) of 1 kW. Separate graphs were prepared for each transmission path.

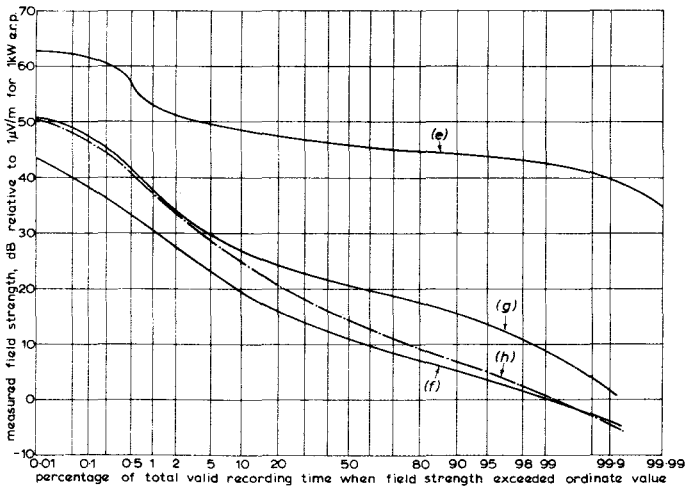
3. RESULTS

3.1. Variation of Field Strength with Time

The results of the Caversham and Mursley Bands I and II measurements are plotted in Fig. 2 as field strength exceeded against percentage of the total valid

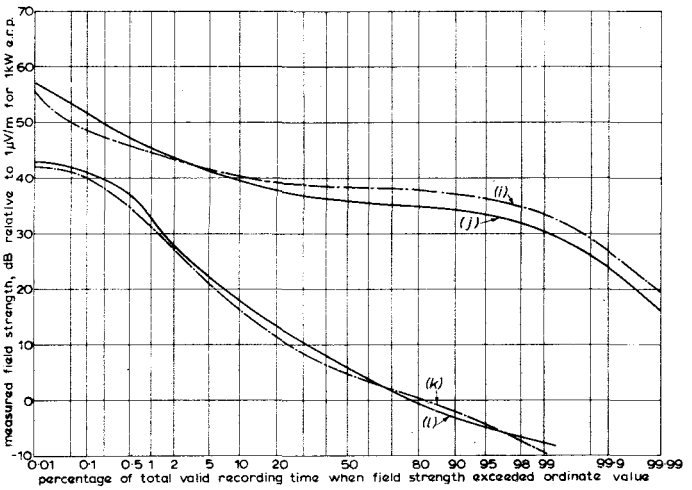


CURVE	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY Mc/s	DISTANCE km	TOTAL HOURS RECORDED	FREE SPACE FIELD dB (μV/m) FOR 1 kW E.R.P.
(a)	Crystal Palace	Caversham	41·5	62·0	7072	71·0
(b)	Peterborough	Caversham	63·27	121·5	6898	65·2
(c)	Sutton Coldfield	Caversham	58·25	138·0	7137	64·1
(d)	Wenvoe	Caversham	63·25	161·0	6923	62·7

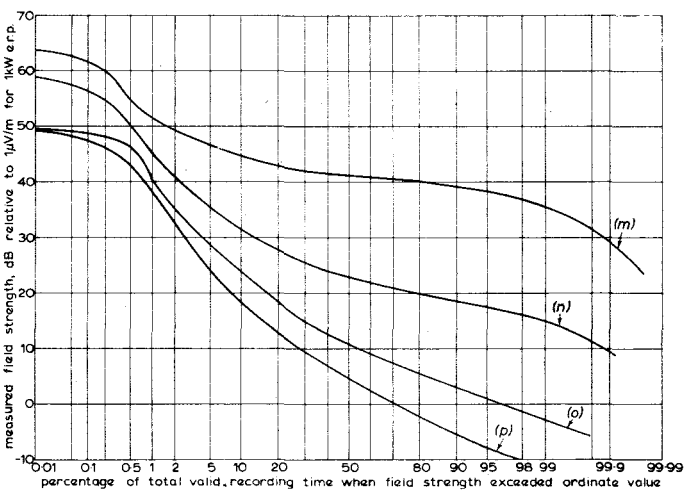


CURVE	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY Mc/s	DISTANCE km	TOTAL HOURS RECORDED	FREE SPACE FIELD dB (μV/m) FOR 1 kW E.R.P.
(e)	Wrotham	Caversham	89·1	88·5	7106	68·0
(f)	Peterborough	Caversham	90·1	121·5	6287	65·2
(g)	Sutton Coldfield	Caversham	88·3	138·0	7115	64·1
(h)	Wenvoe	Caversham	89·95	161·0	6982	62·7

Fig. 2 - Variation of field strength with time



CURVE	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY Mc/s	DISTANCE km	TOTAL HOURS RECORDED	FREE SPACE FIELD dB (μV/m) FOR 1 kW E.R.P.
(*i*)	Crystal Palace	Mursley	41·5	77·5	5814	69·1
(*j*)	Sutton Coldfield	Mursley	58·25	101·0	5507	66·8
(*k*)	Wenvoe	Mursley	63·25	180·0	5508	61·8
(*l*)	North Hessary Tor	Mursley	48·23	274·0	5661	58·2



CURVE	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY Mc/s	DISTANCE km	TOTAL HOURS RECORDED	FREE SPACE FIELD dB (μV/m) FOR 1 kW E.R.P.
(*m*)	Sutton Coldfield	Mursley	88·3	101·0	5912	66·8
(*n*)	Rowridge	Mursley	88·5	146·0	5870	63·5
(*o*)	Wenvoe	Mursley	89·95	180·0	5503	61·8
(*p*)	North Hessary Tor	Murlsey	88·1	274·0	5705	58·2

recording time. The curves for each receiving site and frequency band are shown separately and are accompanied by a table giving the total number of hours relating to each curve and the free-space field strength for the different paths. The field strengths for selected time-percentages derived from Fig. 2 are listed in Table 3.

An inspection of Fig. 2 shows that, in general, the slope of the curves increases with distance. The figures also reveal that the curves converge at the low time-percentage values. This implies that for the high amplitude signals, that is, during abnormal conditions, the signal values are less dependent upon distance.

Curves (*a*), (*e*), (*i*), (*j*) and (*m*) in these figures relate to the shorter paths where, during normal propagation conditions, the signal is virtually constant. During abnormal propagation conditions, however, these signals fade slowly about the median. The signals received over the longer transmission paths are subject to varying degrees of slow and fast fading when propagation conditions are normal. High level signals of virtually constant amplitude are, however, also received at the greater distances when abnormal propagation conditions prevail.

3.2. Range of Fading between Various Time-Percentages

The range of fading is defined as the signal strength exceeded for given percentages of time, expressed as a ratio of the median value. The ranges are given in Table 4 and plotted against distance in Fig. 3(*a*) and (*b*) for Bands I and II respectively. With fading ratios expressed in decibels a linear relationship gave a reasonable approximation to the measurements provided distance is plotted to a logarithmic rather than to a linear scale. This relationship must therefore be taken to give the 'best-fit'.

Two aspects of the fading displayed by the curves are of interest. The high field strength values that occur for less than 10% of the time are important, because in planning broadcast services it is usual to protect a transmission from co-channel interference for at least 90% of the time. From the point of view of reception, and in particular reception for use as a rebroadcast service, it is important to know the incidence of 'fade-outs', that is the ratio of the median to the value occurring for at least 90% of the time, or for at least 99% of the time.

Figs. 3(*a*) and (*b*) show that both in Bands I and II the range of fading increases with distance.

It will be noted that the slope of the 50% - 1% line is in each case greater than the 50% - 99% line, and that the slope of the 50% - 10% line is similarly greater than that of the 50% - 90% line, indicating that the long-term variation of field strength (expressed in decibels) about the median signal value is asymmetrical; the range of fading relative to the median is greater for the low time-percentages than for the high time-percentage values.

Fig. 3(*c*) reproduces, for comparison purposes, the Bands I and II best-fit lines shown in Fig. 3(*a*) and (*b*). It will be seen that at the greater distances Band II signals vary over a wider range than Band I, and although differences exist between the signal characteristics in Bands I and II they are not very great. The combined Bands I and II best-fit lines for the various fading ranges were therefore calculated and appear in Fig. 3(*d*).

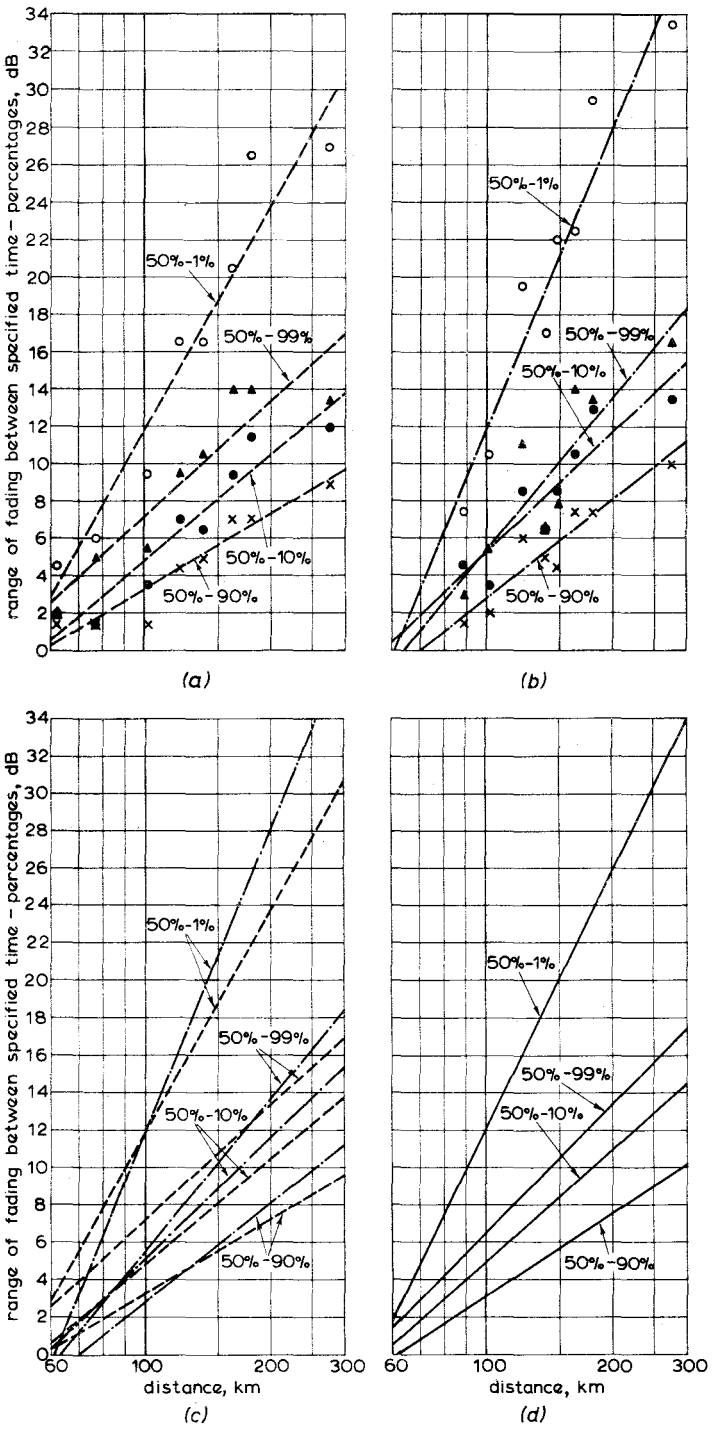
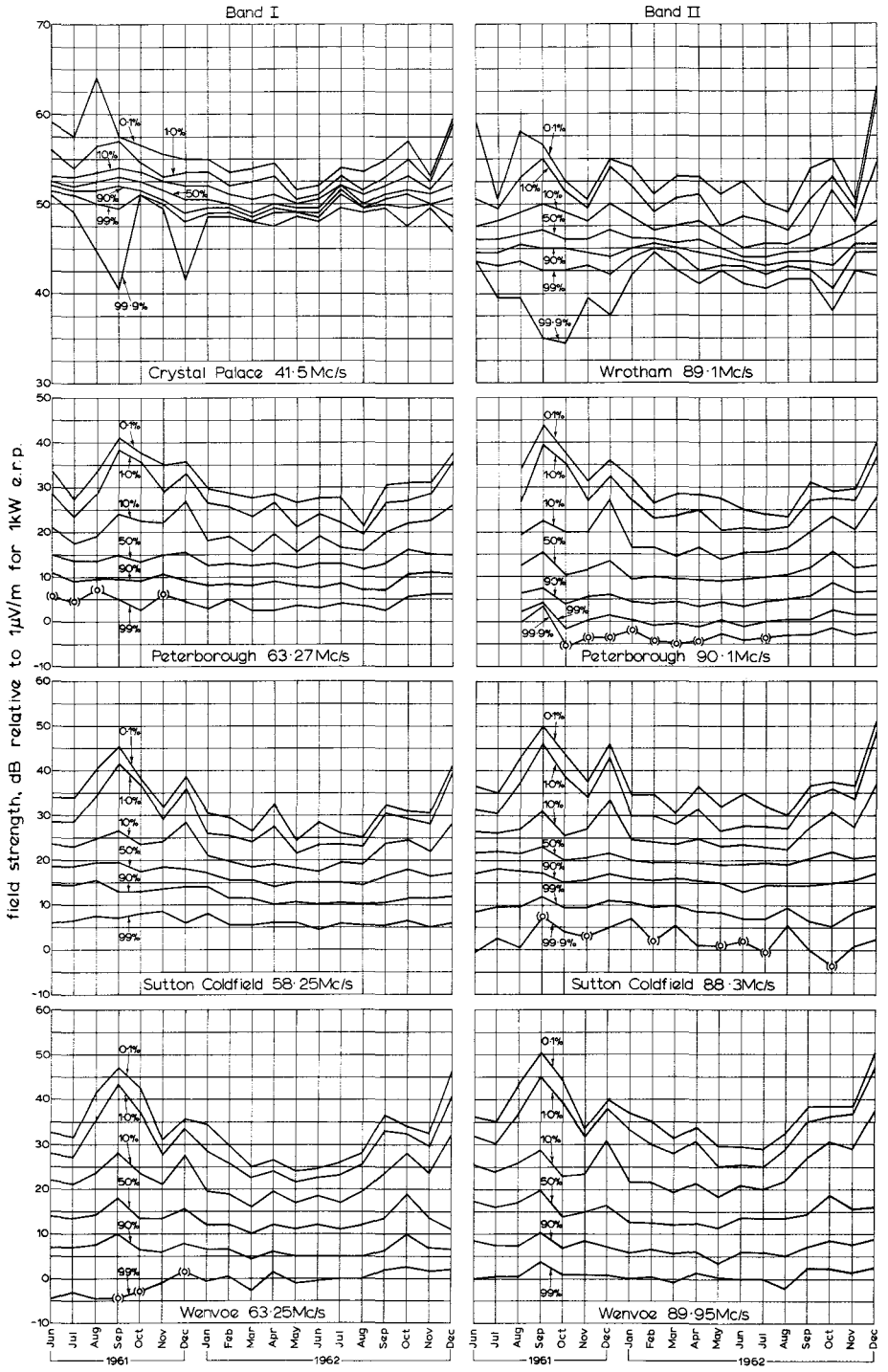


Fig. 3 - Range of fading between various time-percentages

(*a*) Band I (*b*) Band II (*c*) Comparison of Bands I and II (*d*) Combined Bands I and II

o 50% - 1% • 50% - 10% × 50% - 90% ▲ 50% - 99%

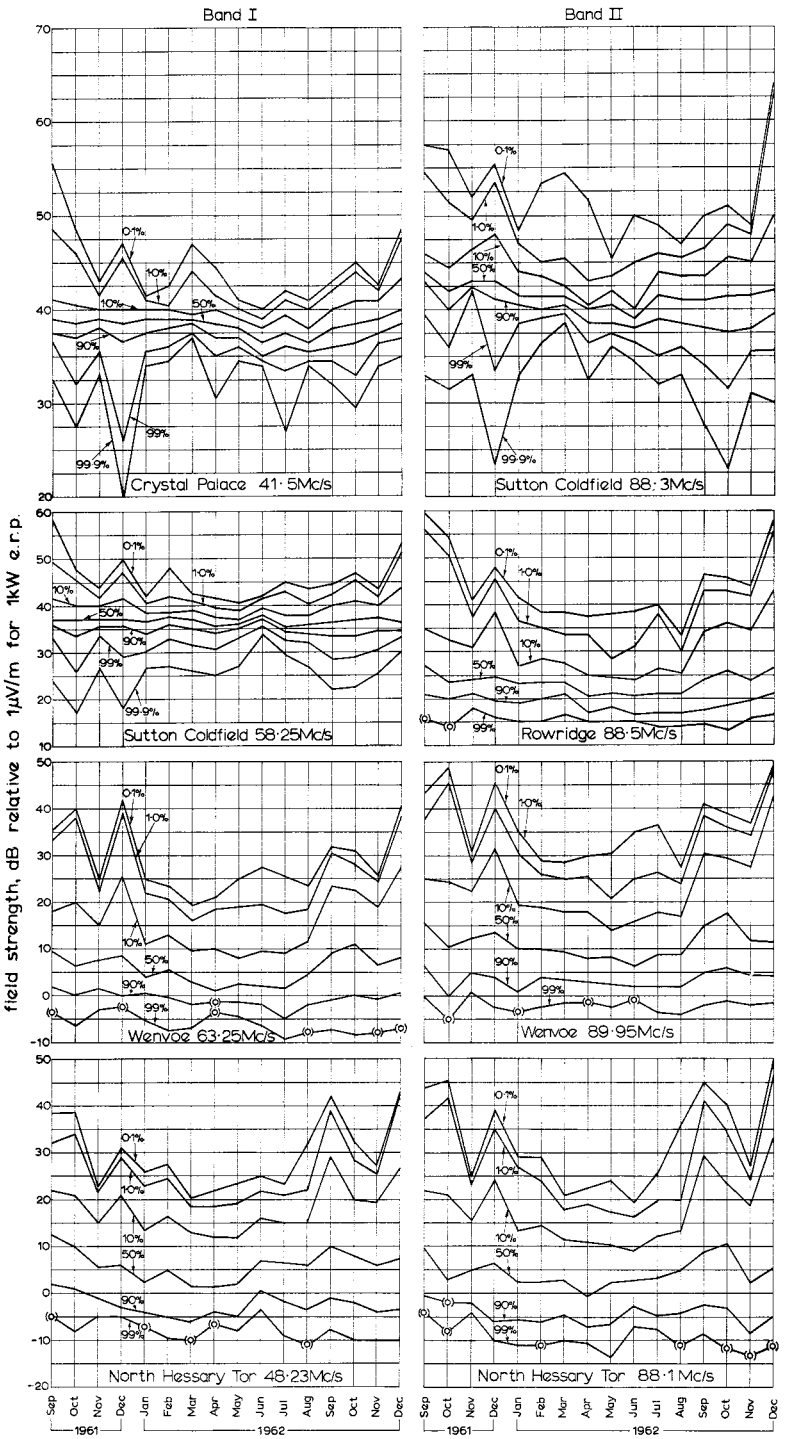
– – – – Band I —·—·— Band II ——— Bands I and II



TRANSMITTER	DISTANCE, km
Crystal Palace	62·0
Wrotham	88·5
Peterborough	121·5
Sutton Coldfield	138·0
Wenvoe	161·0

(0) Extrapolated

Fig. 4 - Field strengths exceeded in each month for selected time-percentages (Caversham)



TRANSMITTER	DISTANCE, km
Crystal Palace	77·5
Sutton Coldfield	101·0
Rowridge	146·0
Wenvoe	180·0
North Hessary Tor	274·0

(0) Extrapolated

Fig. 5 - Field strengths exceeded in each month for selected time-percentages (Mursley)

3.3. Variation of Monthly Field Strengths for Selected Time-Percentages

The field strengths exceeded in each month for selected time-percentages is plotted in order of distance in Figs. 4 and 5. The 99·9 time-percentages could not be given for some of the longer transmission paths as the corresponding field strengths were below the noise level of the receivers.

The standard deviations of these monthly field strengths were calculated for the different transmission paths and selected time-percentages, and are listed in Table 5. Using the values of Table 5, the combined Bands I and II standard deviation best-fit lines for each time-percentage are given in Fig. 6. The standard deviation lines show that the month-to-month field strength variations increase with distance for all time-percentages. In general, the gradient of the line decreases with an increase in time-percentage.

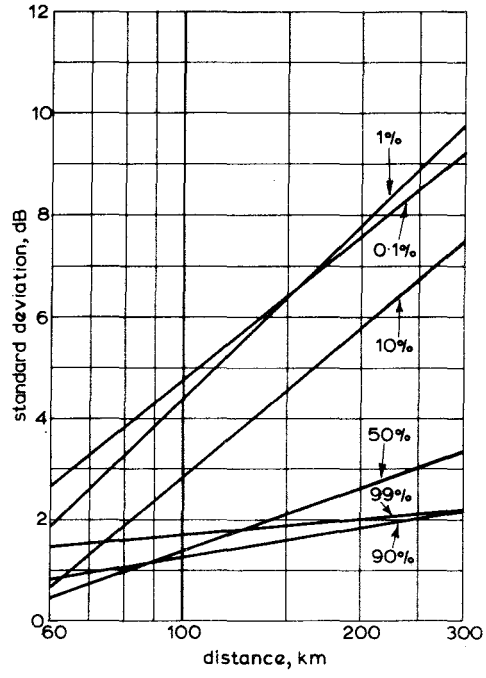


Fig. 6 - Bands I and II - Standard deviation of field strengths exceeded in each month for selected time-percentages

3.4. Variation of Field Strength with Distance

3.4.1. Site Variation Factor

In order to determine whether the two receiving sites chosen for the experiment were representative of the areas in which they were situated, field strength measurements were made at various locations in their vicinity. Measurements of approximately 30 minutes duration were carried out at temporary sites within a radius of 5 miles (8 km) from each permanent site. The ratio of the median field strength at the temporary sites to that for the same period at the permanent site was calculated. The average of these ratios is known as the site variation factor (s.v.f.), and was measured for each transmission frequency and each of the two permanent receiving sites. The appropriate s.v.f. was then used as a correction to the measured field strengths, to give the fields that would have been measured at 50% of locations in the vicinity of each permanent site.

The results of the Caversham and Mursley s.v.f. measurements are given in Appendices I and II respectively. The s.v.f.s obtained from the data in the Appendices are listed in Table 6. These show that with the exceptions of the Band I Peterborough/Caversham and Wenvoe/Mursley transmission paths, the s.v.f.s have negative values, indicating that the Caversham and Mursley sites receive higher fields than the average in their area. Table 6 also reveals that at each receiving site the s.v.f.s vary according to the direction of reception, as would be expected. In addition, for the same transmission path, the s.v.f.s vary with the frequency. The transmission paths involved in this comparison are not identical, as the Bands I and II transmitting aerials are mounted at different heights on the mast and separate receiving aerials are used.

3.4.2. Transmitting Aerial Height Above Mean Terrain

Because there were differences between the heights of the different transmitting sites above the surrounding terrain and the heights of the different transmitting aerials above ground level, it seemed desirable to apply, beside the s.v.f. correction, a correction for the differences in the transmitting aerial heights. This was done for comparison with the CCIR(Geneva 1963) Recommendation 370, in which field-strength/distance curves relating to overland paths are used in the planning of broadcast services. Separate curves are drawn for different transmitter aerial heights above mean terrain for the v.h.f. and u.h.f. frequency bands, mean terrain being somewhat arbitrarily defined as the height of the aerial above the average level of the ground between the distances of 3 km and 15 km from the transmitter.

Table 7 lists the aerial height above mean terrain for each transmission path and also shows the correction derived from the curves in Recommendation 370, which normalises the field strength for other transmitting heights to a height of 300 m. Recommendation 370 gives the field-strength/distance curves for the 1, 10 and 50 time-percentages and thus corrections for these time-percentages only are given in Table 7. The 1% corrections have been used for time-percentages less than 1% and similarly the 50% corrections used for time-percentages greater than 50%. Though not strictly applicable, they help to reduce the differences in field strength due to differences in transmitting aerial height for time-percentage curves for which no values are available in Recommendation 370. These corrections have been applied to the measured field strengths listed in Table 3 and give, together with the s.v.f.s, the corrected values in Table 8.

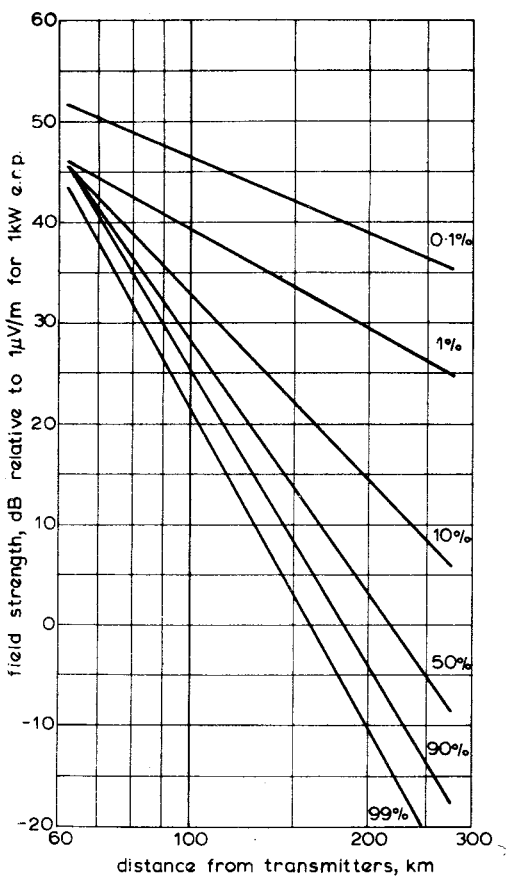


Fig. 7 - Variation of Bands I and II field strengths as a function of distance. The curves show the field strength exceeded for different time-percentages

3.4.3. Field-Strength/Distance Curves

The field strengths (corrected for transmitting aerial height and s.v.f.) listed in Table 8 are used to derive, by the method of least squares, the field-strength/distance curves for selected time-percentages; the results are shown in Fig. 7. The relationship between field-strength plotted in decibels and distance plotted to a logarithmic scale are drawn as straight lines, for the reason given in Section 3.2. This implies an inverse power law relationship between field strength, E, and distance, d, of the form $E = k/d^m$, where k is a parameter related to the transmission paths and to the power of the transmitter. The values of m and 20 log k are given in Table 9.

The field-strength/distance curves in Fig. 7 show that the slope of the curves increases with increasing time-percentage and indicates a reduced dependence of field strength on distance for small time-percentages.

The 1, 10 and 50 time-percentage curves from Fig. 7 are re-drawn in Fig. 8, together with the appropriate CCIR[2] field-strength/distance curves. The BBC Bands I and II measurements cover the frequency range 41·5 to 90·1 Mc/s, whereas the Bands I to III CCIR curves are for the frequency range 40 to 250 Mc/s. The BBC, however, have previously carried out Band III[3] overland measurements utilising a frequency of 180·4 Mc/s and these field-strength/distance curves are also shown in Fig. 8. The Band III measurements, which lasted for a period of almost 3½ years, are corrected for s.v.f. and aerial height of approximately 300 m above mean terrain.

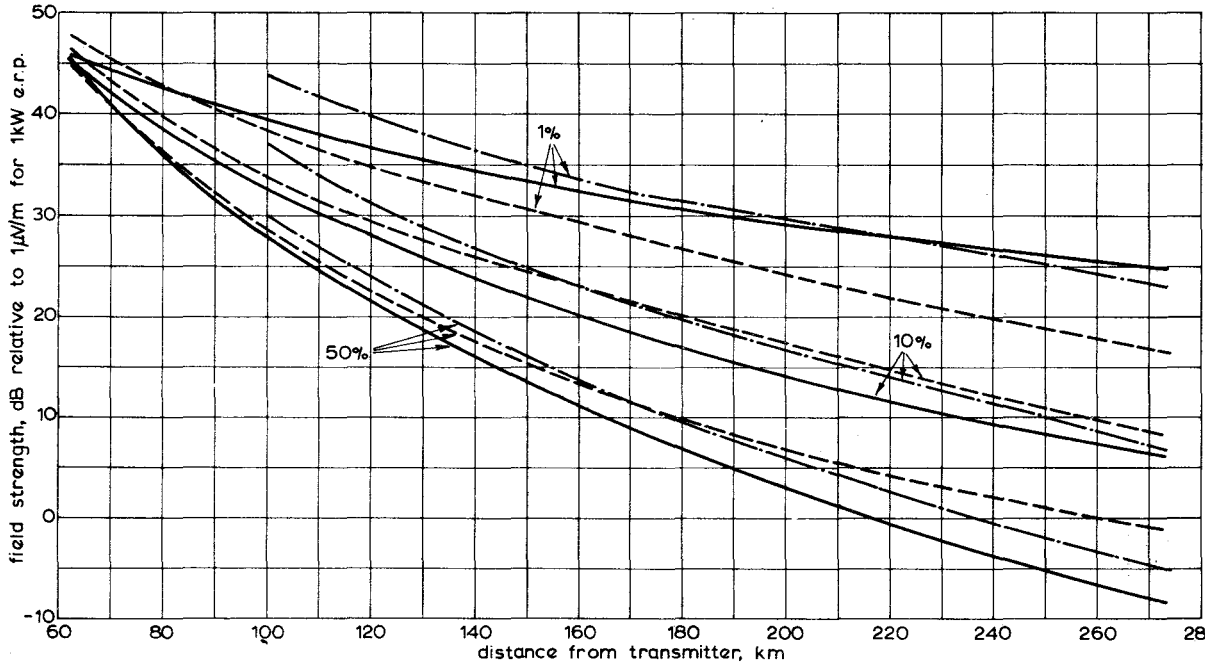


Fig. 8 - Comparison of BBC and CCIR field-strength/distance curves

——— Bands I and II (BBC) —·—·— Band III (BBC)

— — — Bands I to III (CCIR)

An inspection of Fig. 8 reveals that there is good agreement between the BBC Bands I and II curves and the earlier Band III curves. In general, the Band III curves are higher than the Bands I and II curves, but only by a few decibels.

The BBC 1% curves indicate a higher received field than the CCIR 1% curve, the difference increasing to about 8 dB at 274 km. The BBC and CCIR 10% curves are in good agreement. The same applies for the 50% curves up to about 200 km. Beyond 200 km the BBC 50% curves indicate a lower field than the CCIR 50% curve by approximately 2·5 to 5 dB, at least up to 274 km.

4. CONCLUSIONS

The range of fading between the 50 and 1, 50 and 10, 50 and 90, and 50 and 99 time-percentage field strengths increases with distance. The range of fading relative to the median field strength is greater for the low time-percentage field strengths as compared with the high time-percentage values.

The variation of monthly field strengths for the selected time-percentages increases with distance; this is, however, less pronounced for the higher time-percentage values.

The BBC Bands I and II and the Band III field-strength/distance curves are similar. The 10% and 50% BBC curves are in reasonable agreement with the equivalent CCIR curves, but the BBC 1% curves indicate higher fields than the CCIR 1% curve by about 8 dB at 274 km.

5. ACKNOWLEDGEMENTS

The BBC acknowledges with grateful thanks the site facilities given at Mursley by the Buckinghamshire County Constabulary.

Thanks are also due to the Engineer-in-Charge and his staff at the BBC Monitoring Station, Caversham, for the routine maintenance which was carried out on our behalf.

6. REFERENCES

1. 'Equipment for Medium Distance Propagation Tests in Bands I and II', Research Department Report No. K-156, Serial No. 1962/42.

2. Documents of the CCIR Xth Plenary Assembly, Geneva 1963, Vol. II, pp. 24.

3. 'Long Distance Overland Propagation Measurements at 180·4 Mc/s', Research Department Report No. K-140, Serial No. 1959/23.

TABLE 1

Transmitting Site Details

LOCATION	FREQUENCY Mc/s	SITE HEIGHT a.m.s.l. ft	SITE HEIGHT a.m.s.l. m	AERIAL HEIGHT a.g.l. ft	AERIAL HEIGHT a.g.l. m	AERIAL POLARIZATION	LATITUDE	LONGITUDE
Crystal Palace	41·5	362	110	426	130	V	51°25'20"N	00°04'17"W
North Hessary Tor	48·23	1670	509	633	193	V	50°32'59"N	04°00'26"W
North Hessary Tor	88·1	1670	509	538	164	H	50°32'59"N	04°00'26"W
Peterborough	63·27	184	56	418	127	H	53°30'26"N	00°20'30"W
Peterborough	90·1	184	56	325	99	H	53°30'26"N	00°20'30"W
Rowridge	88·5	450	137	296	90	H	50°40'34"N	01°22'02"W
Sutton Coldfield	58·25	555	169	735	224	V	52°35'59"N	01°49'57"W
Sutton Coldfield	88·3	555	169	647	197	H	52°35'59"N	01°49'57"W
Wenvoe	63·25	420	128	735	224	V	51°27'32"N	03°16'48"W
Wenvoe	89·95	420	128	647	197	H	51°27'32"N	03°16'48"W
Wrotham	89·1	720	219	406	124	H	51°19'11"N	00°17'20"E

TABLE 2

Receiving Site Details

RECEIVER LOCATION	TRANSMITTER LOCATION	PATH DISTANCE	RECEIVING SITE						
			SITE HEIGHT a.m.s.l.		APPROXIMATE AERIAL HEIGHT a.g.l.		TRUE BEARING TO TRANSMITTER	LATITUDE	LONGITUDE
		km	ft	m	ft	m			
Caversham	Crystal Palace	62·0	270	82·3	36·0	11·0	95°	51°28'52"N	00°57'23"W
"	Peterborough	121·5	"	"	"	"	19°	"	"
"	Sutton Coldfield	138·0	"	"	"	"	334°	"	"
"	Wenvoe	161·0	"	"	"	"	270°	"	"
"	Wrotham	88·5	"	"	"	"	101°	"	"
Mursley	Crystal Palace	77·5	520	158	30	9·1	140°	51°57'12"N	00°48'05"W
"	North Hessary Tor	274·0	"	"	"	"	236°	"	"
"	Rowridge	146·0	"	"	"	"	195°	"	"
"	Sutton Coldfield	101·0	"	"	"	"	317°	"	"
"	Wenvoe	180·0	"	"	"	"	253°	"	"

TABLE 3

Measured Field Strengths at Caversham and Mursley

CURVES FIG. 2	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY Mc/s	DISTANCE km	FIELD STRENGTH, dB (μV/m) FOR 1 kW E.R.P., EXCEEDED FOR STATED PERCENTAGE OF THE TIME						
					0·1%	1%	10%	50%	90%	99%	99·9%
(*a*)	Crystal Palace	Caversham	41·5	62·0	59·0	55·5	53·0	51·0	49·5	49·0	47·5
(*b*)	Peterborough	"	63·27	121·5	37·0	30·0	20·5	13·5	9·0	4·0	0
(*c*)	Sutton Coldfield	"	58·25	138·0	40·5	33·0	23·0	16·5	11·5	6·0	- 0·5
(*d*)	Wenvoe	"	63·25	161·0	42·5	33·5	22·5	13·0	6·0	- 1·0	- 5·5*
(*e*)	Wrotham	"	89·1	88·5	61·5	53·0	48·5	45·5	44·0	42·5	39·5
(*f*)	Peterborough	"	90·1	121·5	38·5	30·5	19·5	11·0	5·0	0	- 4·0
(*g*)	Sutton Coldfield	"	88·3	138·0	47·5	37·5	27·0	20·5	15·5	9·0	1·5
(*h*)	Wenvoe	"	89·95	161·0	46·5	37·0	25·0	14·5	7·0	0·5	- 4·5
(*i*)	Crystal Palace	Mursley	41·5	77·5	48·5	44·5	40·0	38·5	37·0	33·5	27·0
(*j*)	Sutton Coldfield	"	58·25	101·0	51·5	45·5	39·5	36·0	34·5	30·5	24·0
(*k*)	Wenvoe	"	63·25	180·0	40·0	31·5	16·5	5·0	- 2·0	- 9·0*	N.L.
(*l*)	North Hessary Tor	"	48·23	274·0	41·0	33·0	18·0	6·0	- 3·0	- 7·5	N.L.
(*m*)	Sutton Coldfield	"	88·3	101·0	61·5	51·5	44·5	41·0	39·0	35·5	29·5
(*n*)	Rowridge	"	88·5	146·0	56·5	45·0	31·5	23·0	18·5	15·0	N.L.
(*o*)	Wenvoe	"	89·95	180·0	48·5	40·0	23·5	10·5	3·0	- 3·0	N.L.
(*p*)	North Hessary Tor	"	88·1	274·0	47·5	38·0	18·0	4·5	- 5·5	-12·0*	N.L.

* Extrapolated Value
N.L. Noise Level

TABLE 4

Fading Range Between Time-Percentages

CURVES FIG. 2	TRANSMITTING SITE	RECEIVING SITE	FREQUENCY	DISTANCE	RANGE OF FADING BETWEEN VARIOUS TIME-PERCENTAGES			
			Mc/s	km	50%-1%	50%-10%	50%-90%	50%-99%
(*a*)	Crystal Palace	Caversham	41·5	62·0	4·5	2·0	1·5	2·0
(*b*)	Peterborough	"	63·27	121·5	16·5	7·0	4·5	9·5
(*c*)	Sutton Coldfield	"	58·25	138·0	16·5	6·5	5·0	10·5
(*d*)	Wenvoe	"	63·25	161·0	20·5	9·5	7·0	14·0
(*e*)	Wrotham	"	89·1	88·5	7·5	4·5	1·5	3·0
(*f*)	Peterborough	"	90·1	121·5	19·5	8·5	6·0	11·0
(*g*)	Sutton Coldfield	"	88·3	138·0	17·0	6·5	5·0	6·5
(*h*)	Wenvoe	"	89·95	161·0	22·5	10·5	7·5	14·0
(*i*)	Crystal Palace	Mursley	41·5	77·5	6·0	1·5	1·5	5·0
(*j*)	Sutton Coldfield	"	58·25	101·0	9·5	3·5	1·5	5·5
(*k*)	Wenvoe	"	63·25	180·0	26·5	11·5	7·0	14·0
(*l*)	North Hessary Tor	"	48·23	274·0	27·0	12·0	9·0	13·5
(*m*)	Sutton Coldfield	"	88·3	101·0	10·5	3·5	2·0	5·5
(*n*)	Rowridge	"	88·5	146·0	22·0	8·5	4·5	8·0
(*o*)	Wenvoe	"	89·95	180·0	29·5	13·0	7·5	13·5
(*p*)	North Hessary Tor	"	88·1	274·0	33·5	13·5	10·0	16·5

TABLE 5

Standard Deviation of Monthly Field Strength Variations

TRANSMITTING SITE	RECEIVING SITE	FREQUENCY	DISTANCE	STANDARD DEVIATION FOR SELECTED TIME-PERCENTAGES, dB						
		Mc/s	km	0·1%	1%	10%	50%	90%	99%	99·9%
Crystal Palace	Caversham	41·5	62·0	2·98	2·17	1·28	1·20	1·13	1·03	2·77
Peterborough	"	63·27	121·5	4·76	5·12	3·37	1·28	1·27	1·41	-
Sutton Coldfield	"	58·25	138·0	5·82	5·80	3·37	1·72	1·76	1·07	-
Wenvoe	"	63·25	161·0	7·08	6·34	4·28	2·32	1·52	2·35	-
Wrotham	"	89·1	88·5	3·60	3·41	2·12	1·04	0·85	1·09	2·67
Peterborough	"	90·1	121·5	5·74	5·90	4·16	2·04	1·42	1·55	2·11
Sutton Coldfield	"	88·3	138·0	6·13	4·47	3·90	1·18	1·26	1·60	2·82
Wenvoe	"	89·95	161·0	6·38	6·29	4·86	2·40	1·47	1·34	-
Crystal Palace	Mursley	41·5	77·5	3·98	2·85	1·29	1·0	1·03	2·73	4·76
Sutton Coldfield	"	58·25	101·0	4·74	3·51	1·79	0·71	1·03	2·41	4·21
Wenvoe	"	63·25	180·0	7·15	8·08	6·52	3·12	1·66	2·15	-
North Hessary Tor	"	48·23	274·0	7·28	7·25	5·06	3·18	2·31	2·29	-
Sutton Coldfield	"	88·3	101·0	4·58	5·11	2·58	1·19	1·61	2·64	4·22
Rowridge	"	88·5	146·0	7·67	8·64	5·66	2·09	1·64	1·17	-
Wenvoe	"	89·95	180·0	7·22	8·27	7·62	3·01	1·75	1·50	-
North Hessary Tor	"	88·1	274·0	9·93	10·17	7·29	3·06	2·10	2·79	-

TABLE 6

Site Variation Factors

TRANSMITTING SITE	RECEIVING SITE	FREQUENCY	SITE VARIATION FACTOR
		Mc/s	dB
Crystal Palace	Caversham	41·5	-12·0
Peterborough	"	63·27	+ 3·5
Sutton Coldfield	"	58·25	- 5·0
Wenvoe	"	63·25	-15·0
Wrotham	"	89·1	- 4·5
Peterborough	"	90·1	- 2·5
Sutton Coldfield	"	88·3	- 8·0
Wenvoe	"	89·95	-10·5
Crystal Palace	Mursley	41·5	- 7·5
Sutton Coldfield	"	58·25	- 5·0
Wenvoe	"	63·25	+ 4·0
North Hessary Tor	"	48·23	- 6·0
Sutton Coldfield	"	88·3	-10·0
Rowridge	"	88·5	-10·5
Wenvoe	"	89·95	- 0·5
North Hessary Tor	"	88·1	- 5·0

TABLE 7

Corrections for a Transmitting Aerial Height Above Mean Terrain of 300 metres

TRANSMITTING SITE	RECEIVING SITE	FREQUENCY	DISTANCE	AERIAL HEIGHT ABOVE MEAN TERRAIN	CORRECTIONS TO NORMALISE THE MEASURED FIELD STRENGTHS FOR AN AERIAL HEIGHT OF 300 METRES ABOVE MEAN TERRAIN. dB		
		Mc/s	km	m	1%	10%	50%
Crystal Palace	Caversham	41·5	62·0	160	+4·5	+6·0	+7·0
Peterborough	"	63·27	121·5	183	+1·5	+2·0	+3·0
Sutton Coldfield	"	58·25	138·0	325	-0·5	-0·5	-0·5
Wenvoe	"	63·25	161·0	234	+1·0	+1·0	+1·0
Wrotham	"	89·1	88·5	250	+1·0	+1·0	+1·5
Peterborough	"	90·1	121·5	155	+2·5	+4·0	+4·0
Sutton Coldfield	"	88·3	138·0	298	0	0	0
Wenvoe	"	89·95	161·0	207	+1·0	+1·5	+2·5
Crystal Palace	Mursley	41·5	77·5	150	+3·5	+5·5	+6·0
Sutton Coldfield	"	58·25	101·0	315	-0·5	-0·5	-0·5
Wenvoe	"	63·25	180·0	235	+0·5	+0·5	+0·5
North Hessary Tor	"	48·23	274·0	583	-3·0	-3·5	-4·0
Sutton Coldfield	"	88·3	101·0	287	+0·5	+0·5	0
Rowridge	"	88·5	146·0	99	+3·5	+5·5	+5·5
Wenvoe	"	89·95	180·0	208	+1·5	+2·0	+1·5
North Hessary Tor	"	88·1	274·0	554	-2·0	-3·5	-3·5

TABLE 8

Field Strength Corrected for s.v.f. and Transmitter Aerial Height Above Mean Terrain of 300 Metres

TRANSMITTING SITE	RECEIVING SITE	FREQUENCY	DISTANCE	FIELD STRENGTH, dB (μV/m) FOR 1 kW, E.R.P. (CORRECTED FOR S.V.F. AND MEAN TERRAIN) EXCEEDED FOR STATED PERCENTAGE OF THE TIME						
		Mc/s	km	0·1%	1%	10%	50%	90%	99%	99·9%
Crystal Palace	Caversham	41·5	62·0	51·5	48·0	47·0	46·0	44·5	44·0	42·5
Peterborough	"	63·27	121·5	42·0	35·0	26·0	20·0	15·5	10·5	6·5
Sutton Coldfield	"	58·25	138·0	35·0	27·5	17·5	11·0	6·0	0·5	- 6·0
Wenvoe	"	63·25	161·0	28·5	19·5	8·5	-1·0	- 8·0	-15·0	-19·5
Wrotham	"	89·1	88·5	58·0	49·5	45·0	42·5	41·0	39·5	36·5
Peterborough	"	90·1	121·5	38·5	30·5	21·0	12·5	6·5	1·5	- 2·5
Sutton Coldfield	"	88·3	138·0	39·5	29·5	19·0	12·5	7·5	1·0	- 6·5
Wenvoe	"	89·95	161·0	37·0	27·5	16·0	6·5	- 1·0	- 7·5	-12·5
Crystal Palace	Mursley	41·5	77·5	44·5	40·5	38·0	37·0	35·5	32·0	25·5
Sutton Coldfield	"	58·25	101·0	46·0	40·0	34·0	30·5	29·0	25·0	18·5
Wenvoe	"	63·25	180·0	44·5	36·0	21·0	9·5	2·5	- 4·5	-
North Hessary Tor	"	48·23	274·0	32·0	24·0	8·5	-4·0	-13·0	-17·5	-
Sutton Coldfield	"	88·3	101·0	52·0	42·0	35·0	31·0	29·0	25·5	19·5
Rowridge	"	88·5	146·0	49·5	38·0	26·5	18·0	13·5	10·0	-
Wenvoe	"	89·95	180·0	49·5	41·0	25·0	11·5	4·0	- 2·0	-
North Hessary Tor	"	88·1	274·0	40·5	31·0	9·5	-4·0	-14·0	-20·5	-

TABLE 9

Field Strength/Distance Parameters

TIME-PERCENTAGE	m	20logk
0·1	-1·252	96·3
1	-1·608	103·4
10	-3·047	154·6
50	-4·165	194·7
90	-4·916	221·7
99	-5·312	233·8

APPENDIX I

Site Variation Factor (s.v.f.) Measurements Made in the Caversham Area

TEST NO.	SITE LOCATION	GRID REFERENCE (100 km SQUARE SU)	SITE HEIGHT a.m.s.l.		DISTANCE FROM PERMANENT SITE	SITE DETAILS
			ft	m	km	
1	Battle Hospital	697733	150	45·7	4·0	Houses and other buildings all round.
2	Binfield Heath	747785	305	93·0	3·2	Trees and houses.
3	Bottom Farm	672773	164	50·0	5·3	In valley with many trees.
4	Crowsley Park	722803	280	85·3	3·9	Level site but large number of trees.
5	Greys Court	733836	350	106·7	7·2	Open site with trees approximately 1/4 mile away.
6	Harpsden	768811	130	39·6	6·4	Open site with trees in vicinity.
7	Holy Brook	681710	130	39·6	6·8	A few low trees in vicinity.
8	Kidmore End	699793	310	94·5	3·9	Houses and tall trees close to site.
9	Loddon Bridge	768714	126	38·4	6·6	Good open site.
10	Nippers Grove	681814	400	121·9	6·6	Trees within 50 yards.
11	Purley	662764	150	45·7	6·1	River valley with few trees and houses near site.
12	Ruscombe	798763	155	47·2	7·2	Tall trees on all sides.
13	Sonning	772757	140	42·7	4·7	Open site with ground rising slightly in south-west.
14	Whitenights Park	727721	235	71·6	4·2	Shops and houses all round.
15	Whitley Wood	722689	155	47·2	7·2	Flat open site with a few houses and trees in vicinity.
16	Woodlands	753736	150	45.7	4.0	Open site with few low trees and bushes.

APPENDIX I (cont.)

Site Variation Factor (s.v.f.) Measurements Made in the Caversham Area

TEST NO.	CRYSTAL PALACE 41·5 Mc/s			SUTTON COLDFIELD 58·25 Mc/s			WENVOE 63·25 Mc/s			PETERBOROUGH 63·27 Mc/s			SUTTON COLDFIELD 88·3 Mc/s			WROTHAM 89·1 Mc/s			WENVOE 89·95 Mc/s			PETERBOROUGH 90·1 Mc/s		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	41·0	53·0	-12·0	9·5	12·0	- 2·5	4·0	14·0	-10·0	10·0	9·5	+0·5	10·5	18·5	- 8·0	38·0	41·5	- 3·5	8·5	14·5	- 6·0	4·0	5·5	- 1·5
2	40·5	52·5	-12·0	12·0	12·0	0	-13·5	9·0	-22·5	12·5	9·0	+3·5	13·0	18·0	- 5·0	41·0	41·0	0	-4·0	7·0	-11·0	4·5	7·5	- 3·0
3	42·5	53·0	-10·5	12·5	15·5	- 3·0	- 6·0	11·5	-17·5	9·0	6·5	+2·5	11·5	17·5	- 6·0	41·0	42·5	- 1·5	-4·0	11·0	-15·0	6·0	6·5	- 0·5
4	29·5	53·0	-23·5	7·0	14·5	- 7·5	- 1·0	11·5	-12·5	1·0	8·0	-7·0	2·5	19·5	-17·0	25·0	43·5	-18·5	-4·0	9·0	-13·0	-4·0	7·0	-11·0
5	39·5	53·0	-13·5	12·5	15·5	- 3·0	-13·5	11·5	-25·0	10·5	8·0	+2·5	17·0	19·5	- 2·5	37·0	43·0	- 6·0	-6·5	12·0	-18·5	3·0	10·0	- 7·0
6	50·0	53·0	- 3·0	15·5	12·5	+ 3·0	5·5	13·0	- 7·5	28·0	20·0	+8·0	14·5	18·0	- 3·5	49·0	42·0	+ 7·0	4·0	9·5	- 5·5	18·5	18·5	0
7	46·5	53·0	- 6·5	9·0	12·5	- 3·5	- 2·0	10·5	-12·5	15·5	7·0	+8·5	14·0	19·0	- 5·0	45·0	41·5	+ 2·5	1·0	9·5	- 8·5	7·0	5·0	+ 2·0
8	41·0	53·5	-12·5	1·5	14·5	-13·0	0	8·0	- 8·0	16·0	11·0	+5·0	13·0	17·5	- 4·5	39·0	43·0	- 4·0	0·5	12·5	-12·0	7·0	10·0	- 3·0
9	39·5	53·5	-14·0	7·0	14·0	- 7·0	- 9·5	8·5	-17·5	15·0	8·0	+7·0	13·0	18·0	- 5·0	34·5	41·0	- 6·5	1·5	9·5	- 8·0	9·5	9·5	0
10	41·5	52·5	-11·0	0	11·5	-11·5	-11·0	8·0	-19·0	11·5	8·0	+3·5	3·0	18·5	-15·5	37·0	40·5	- 3·5	-1·5	7·5	- 9·0	5·0	6·5	- 1·5
11	39·0	53·0	-14·0	9·5	14·0	- 4·5	- 1·5	7·5	- 9·0	11·0	7·0	+4·0	11·5	16·5	- 5·0	34·0	40·5	- 6·5	8·5	11·5	- 3·0	5·5	8·5	- 3·0
12	38·0	52·0	-14·0	5·5	15·5	-10·0	- 1·5	8·0	- 9·5	10·5	8·0	+2·5	7·0	17·5	-10·5	36·5	40·5	- 4·0	8·0	10·0	- 2·0	5·0	6·5	- 1·5
13	42·5	52·0	- 9·5	11·5	14·5	- 3·0	- 4·0	12·0	-16·0	12·5	9·0	+3·5	11·5	20·5	- 9·0	40·0	43·5	- 3·5	9·5	19·0	- 9·5	3·0	7·5	- 4·5
14	42·5	52·0	- 9·5	17·0	15·0	+ 2·0	- 7·5	9·5	-17·0	19·0	12·0	+7·0	15·0	16·5	- 1·5	43·5	43·5	0	0·5	11·0	-10·5	9·0	6·5	+ 2·5
15	43·0	52·0	- 9·0	18·5	29·0	-10·5	2·5	15·5	-13·0	7·5	7·0	+0·5	14·5	29·5	-15·0	37·0	41·0	- 4·0	8·5	23·0	-14·5	7·5	8·0	- 0·5
16	33·5	52·0	-18·5	9·5	16·5	- 7·0	1·0	21·5	-20·5	6·5	4·0	+2·5	8·5	22·5	-14·0	25·0	42·0	-17·0	-0·5	19·0	-19·5	5·5	10·0	- 4·5
S.V.F. (to nearest 0·5 dB)			-12·0			- 5·0			-15·0			+3·5			- 8·0			- 4·5			-10·5			- 2·5

A Field strength at temporary site (dB(μV/m) for 1 kW e.r.p.)

B Field strength at permanent site (dB(μV/m) for 1 kW e.r.p.)

C Comparison of field strength of temporary with permanent site (dB(μV/m) for 1 kW e.r.p.)

APPENDIX II

Site Variation Factor (s.v.f.) Measurements Made in the Mursley Area

TEST NO.	SITE LOCATION	GRID REFERENCE (100 km SQUARE SP)	SITE HEIGHT a.m.s.l.		DISTANCE FROM PERMANENT SITE	SITE DETAILS
			ft	m	km	
1	Adstock	738308	365	111·3	8·7	Large trees 75 yards to south of site.
2	Bletchley	873348	250	76·2	7·4	Open site beside main road, factories to south of site.
3	Borough Farm	856312	340	103·6	3·9	Clear of trees for 200 yards.
4	Cublington	832216	330	100·6	7·6	Site in valley.
5	East Claydon	736254	400	121·9	9·3	Trees around site at 50 yards to the east and 200 yards to the west.
6	Great Horwood	783313	425	129·5	4·7	Open country with scattered trees.
7	Great Horwood Common	778322	420	128·0	5·6	Cross-roads, no trees or buildings within 1/4 mile.
8	Liscombe Park	882252	400	121·9	7·1	Open site but thick belt of trees running east/west to the north of the site at a distance of 1/3 mile.
9	Newton Longville	839316	350	106·7	2·9	Railway and bridge north-west of site, trees to south.
10	Oving	786218	500	152·4	8·0	Open site, cottages on slight rise east of site.
11	Potash Farm	833281	470	143·3	1·4	Open country with slight rise towards fixed site.
12	Shenley Church End	829375	270	82·3	8·0	Slight screening by trees to south and west.
13	Soulbury	873268	470	143·2	5·5	Open site.
14	Stoke Hammond	875299	320	97·5	5·3	On crest of small rise, some trees nearby.
15	Thornton	762364	300	91·4	9·6	Open site, ground falling away all round.
16	Whaddon	798344	350	106·7	5·6	Land rising slightly east of site.
17	Winslow	779265	305	93·0	5·2	Site in valley, some large trees at 200 yards.

APPENDIX II (cont.)

Site Variation Factor (s.v.f.) Measurements Made in the Mursley Area

TEST NO.	CRYSTAL PALACE 41·5 Mc/s			NORTH HESSARY TOR 48·23 Mc/s			SUTTON COLDFIELD 58·25 Mc/s			WENVOE 63·25 Mc/s			NORTH HESSARY TOR 88·1 Mc/s			SUTTON COLDFIELD 88·3 Mc/s			ROWRIDGE 88·5 Mc/s			WENVOE 89·95 Mc/s		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	27·0	37·0	-10·0	15·5	11·0	+ 4·5	33·0	36·0	- 3·0	3·5	0·5	+ 3·0	0	-3·0	+ 3·0	33·5	41·5	- 8·0	7·5	22·0	-14·5	8·0	7·0	+ 1·0
2	29·0	37·0	- 8·0	- 2·5	13·0	-15·5	31·5	43·0	-11·5	6·0	13·0	- 7·0	0	13·5	-13·5	23·5	41·5	-18·0	1·5	23·0	-21·5	6·5	11·5	- 5·0
3	31·0	36·5	- 5·5	- 3·0	7·0	-10·0	27·5	35·0	- 7·5	6·0	5·5	+ 0·5	4·5	8·0	- 3·5	30·5	41·0	- 9·5	16·0	23·0	- 7·0	11·0	14·0	- 3·0
4	25·5	39·0	-13·5	11·5	20·0	- 8·5	25·0	33·5	- 8·5	15·0	4·0	+11·0	16·5	26·5	-10·0	22·0	40·5	-18·5	26·0	30·0	- 4·0	10·5	11·5	- 1·0
5	33·0	36·0	- 3·0	0	2·5	- 2·5	34·0	34·5	- 0·5	11·5	4·0	+ 7·5	6·0	9·5	- 3·5	34·0	37·0	- 3·0	18·0	20·0	- 2·0	21·5	15·0	+ 6·5
6	31·0	36·0	- 5·0	8·0	12·0	- 4·0	31·5	34·5	- 3·0	5·5	1·5	+ 4·0	10·0	7·5	+ 2·5	31·5	41·5	-10·0	19·0	20·5	- 1·5	20·0	18·0	+ 2·0
7	29·5	38·5	- 9·0	5·0	12·0	- 7·0	37·0	36·5	+ 0·5	14·0	3·0	+11·0	5·5	2·0	+ 3·5	37·0	40·0	- 3·0	22·5	24·0	- 1·5	11·0	7·5	+ 3·5
8	36·0	35·0	+ 1·0	-10·0	-4·5	+ 5·5	27·0	34·5	- 7·5	14·5	5·0	+ 9·5	24·5	32·5	- 8·0	25·5	40·0	-14·5	24·5	32·0	- 7·5	13·0	8·5	+ 4·5
9	29·5	39·5	-10·0	- 0·5	10·0	- 9·5	26·5	35·0	- 8·5	5·0	4·0	+ 1·0	3·0	14·5	-11·5	27·0	40·5	-13·5	3·5	23·0	-19·5	11·0	14·5	- 3·5
10	35·0	35·5	- 0·5	4·0	9·0	- 5·0	41·0	34·0	+ 7·0	13·0	-0·5	+12·5	3·5	-3·5	+ 7·0	44·5	40·0	+ 4·5	6·0	24·5	-18·5	13·5	6·0	+ 7·5
11	31·5	45·0	-13·5	9·0	10·0	- 1·0	27·5	37·5	-10·0	7·5	0	+ 7·5	10·0	6·5	+ 3·5	29·0	39·5	- 9·5	18·5	21·5	- 3·0	13·0	8·5	+ 4·5
12	26·5	36·5	-10·0	2·5	13·5	-11·0	28·5	37·0	- 8·5	8·5	14·0	- 5·5	2·5	16·5	-14·0	23·5	37·5	-14·0	10·5	20·0	- 9·5	7·0	17·0	-10·0
13	37·0	31·5	+ 5·5	11·5	20·0	- 8·5	36·5	35·5	+ 1·0	13·5	6·0	+ 7·5	10·0	20·0	-10·0	43·5	45·0	- 1·5	25·5	28·0	- 2·5	20·0	20·0	0
14	31·0	36·5	- 5·5	- 6·5	4·5	-10·5	30·0	36·5	- 6·5	2·0	6·0	- 4·0	3·0	13·5	-10·5	28·5	39·0	-10·5	8·5	25·5	-17·0	13·0	15·0	- 2·0
15	21·0	38·5	-17·5	2·5	4·5	- 2·0	30·0	35·0	- 5·0	-1·0	-3·0	+ 2·0	-10·0	-6·0	- 4·0	31·0	43·5	-12·5	9·0	30·5	-21·5	3·0	8·0	- 5·0
16	24·5	37·0	-12·5	- 4·5	10·0	-14·5	32·0	36·0	- 4·0	4·5	2·0	+ 2·5	- 2·5	6·0	- 8·5	31·5	41·5	-10·0	5·5	22·0	-16·5	6·5	11·5	- 5·0
17	31·0	39·5	- 8·5	- 2·0	2·0	- 4·0	30·0	39·0	- 9·0	16·5	14·0	+ 2·5	- 2·0	2·5	- 4·5	27·0	43·5	-16·5	12·5	22·5	-10·0	11·0	17·5	- 6·5
S.V.F. (to nearest 0·5 dB)			- 7·5			- 6·0			- 5·0			+ 4·0			- 5·0			-10·0			-10·5			-0·5

A Field strength at temporary site (dB(μV/m) for 1 kW e.r.p.)

B Field strength at permanent site (dB(μV/m) for 1 kW e.r.p.)

C Comparison of field strength of temporary with permanent site (dB(μV/m) for 1 kW e.r.p.)

Printed by BBC Research Department, Kingswood Warren, Tadworth, Surrey